LEAF DISEASE DETECTION USING MASK-RCNN

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Abstract
The domain which has high effect in human's life is Agriculture. Most of the farmers face leaf disease problem because of which they face loss in agricultural productivity. Farmers find it difficult to detect and rectify the diseases that occur in leaf due to lack of knowledge that leads to loss in agricultural products. It is only possible to achieve healthy nutrition if the crop is yield healthy. In today's date the technology is developed in such a way that the devices are faster and smart enough to recognize and detect disease in leaf which helps farmers in monitoring the farms and also reduce work of farmers. In this approach it focuses on detecting the leaf disease using "Artificial Intelligence" concepts like deep learning techniques. This approach uses open dataset of 200 and above leaf images that contains three types of leaf parasites and also normal leaf, were CNN is used and classification head of the CNN is used to predict the disease and Mask R-CNN is used to mask exact parasite hosted of leaf.
Keywords: Leaf Disease, AI, CNN, Mask-RCNN.

I. INTRODUCTION

The good heaths of human rely on the kind of food they absorb. If the crop is unhealthy, it will affect human by producing different types of health problems because of poor nutrition. Thus it is only possible to achieve healthy nutrition if the crop is yield healthy. Any sort of disease in plants produces unhealthy crops. Therefore, detecting disease in leaf is most essential and effective step in raising healthy crops.

However, manual detection of diseases in leaf takes more time and is not much accurate. Therefore it is now possible using advance technology. Advance technology of "Artificial Intelligence" such as Deep learning technology can give accurate prediction of the disease in leaf. An ordinary human's observation cannot accurately predict the disease infected in leaf.

This proposed system aims to support and help farmers to protect their crops from any type of pests and disease getting infected without harming cultivation and other crops in farms. It aims to detect the type of pest or

disease in leaf and also it will mask the exact parasite hosted on leaf. Using "Artificial Intelligence" concept
the agriculture system is now changed into a "Digital Agricultural System". Several practice and test have proved that increase in development of technology will automatically increase the yielding of good agricultural products.

This process is accomplished by performing few important steps: creating dataset for predicting disease, creating labels, pre-processing (leaf images), undergoes trains-tests split stage, create CNN model for training the dataset to predict the type of disease infected, Then
Create dataset for masking and perform data annotation, pass the image to masking parameter of Mask R-CNN algorithm, obtain the region and mask over infected area.

II. RELATED WORK

Suma V, R Amog Shetty, Rishab F Tated and Sunku Rohan focused on detecting plant disease using approach termed image processing. It utilized dataset of 500 images of healthy and non healthy plant, where convolution neural network and semi supervised algorithm are used to detect the sickness status of 4 distinct classes and characterize crop species.

Qimei Wang, Feng Qi, Minghe sun, Jainhua Qu and Jie Xue focused on predicting disease in tomato and detecting the exact areas infecting in tomato using technique called object detection and Deep Convolutional Neural Network.

III. SYSTEM DESIGN AND ARCHITECTURE

- **Materials and Methods used for predicting type of disease in leaf are:**

1. Leaf Dataset:

Open dataset of 200 and above leaf images are used to make project. It contains 4 distinct classes in which there are 3 types of leaf parasite those are Bacteria, Fungi and Nematodes and it also contains healthy leaf.

2. Creation of Labels:

Labels are the meaningful tags that are given to the images. Here labels are created for each leaf images in dataset which gives the information of particular leaf image. Labels are created using excel and saved in format as common separated values.

3. Algorithm used is Convolution Neural Network (CNN):

CNN is a deep learning algorithm which is also called as ConvNets. It is mainly used in image processing to find patterns in image. The requirements are much lesser as compared to other classification algorithms.

CNN performs four operations:

1. Convolution:

The goal of this operator is to extract features of input image. It learns features of images and coordinates with pixel values by using squares of input images.

2. Activation:

It is performed after every convolution operation. It is used in CNN with the purpose of introducing non- linearity. There are many activation functions; the function used in this project is ReLU (Rectified Linear Unit).

3. Pooling:

Pooling is applied to reduce the Spatial Dimension.

Here the dimensionality of individual feature map is reduced while maintaining the essential data. The type of pooling layer used to make this project is Max Pooling in which largest element of the feature rectified map is taken.

4. Fully Connected:

Aggregates or sums up all the information from the final feature maps into a single vector value (i.e. generates final classification). Activation function is changed to softmax in this operation because it works on any arbitrary real valued vector and transforms into a vector value to acquire sum of 1.

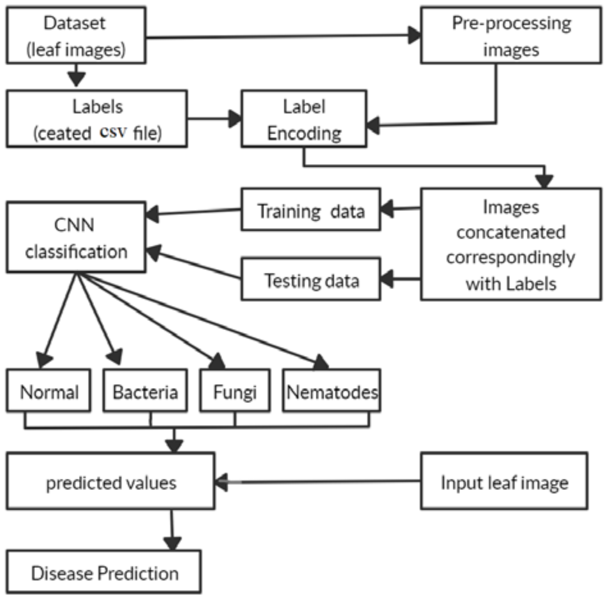


Fig1: Shows the process of predicting type of disease in leaf.

- **Materials and Methods used for masking exact parasite hosted on leaf:**

1. Leaf Dataset:

Here we use only 3 types of leaf parasite images which are used for predicting the type of disease in leaf.

2. Data Annotation:

Tool used is Image Annotation. It is a process of labeling image in which objects of interest in images are annotated with appended metadata so that it can be recognized by machine through computer vision. Software used to perform Image Annotation is VGG Image Annotation 1.0.1 and labeling technique used is polygon annotation.

3. Algorithm used is Mask-RCNN:

It is also a deep learning algorithm used for detecting objects in images. It is built on top of Faster-RCNN which will output a class label, a bounding box and also outputs the mask on the object.

Mask-RCNN performs four main operations:
Before performing various operations of Mask-RCNN it is important to know about Image Segmentation. There will be many parts in the image so it not possible to process entire image because it will contain many regions and certain region that may not have any information's so by dividing the image into parts which is also called as segments, we can use only the necessary segments for processing image.
The Image segmentation is of two types:

a. Semantic Segmentation:
It is segmentation process were all the pixel belongs to a particular class and is masked with one color.

b. Instance Segmentation:
It is a process in which a particular class is assigned to each pixel of image and is presented with different colors.
In this project work we focus on Instance segmentation.

1. Backbone of model:

The backbone model of In Mask-RCNN is ResNet 101 architecture. It is used to extract the features from the images. The extracted features are given as input to the next layer.

2. Region Proposal Network (RPN):

The features obtained by ResNet are given as input to RPN. This will predict whether the object is present in region or not.

3. Region of Interest (ROI):

To reduce the computation time ROI is calculated. So for the entire predicted regions given by RPN, computes the Intersection over Union (IOU) with the ground truth boxes.

$$IOU = \frac{\text{Area of the Intersection}}{\text{Area of the Union}} \quad \text{Eqn(1)}$$

If IOUs of each computed region is greater than or equal to 0.5 then it is considered as region of interest otherwise the rest are neglected.

4. Segmentation Mask:

Now that we have got ROI found on IOU esteems. This will give us the Segmentation Mask for each region which contains an object. It returns a mask of 28*28 for each region which is then scaled up in inference.

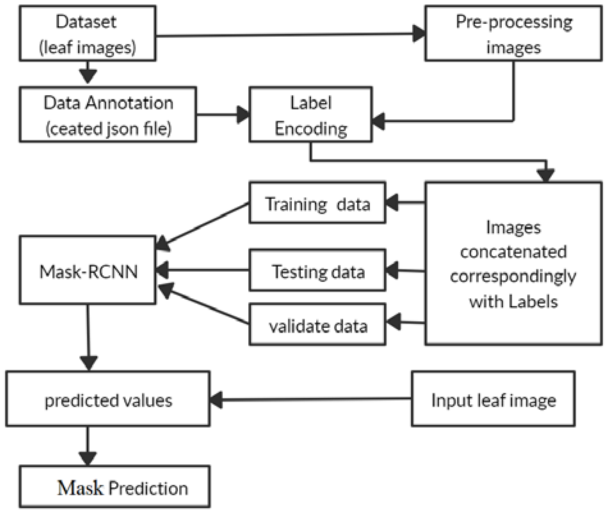


Fig2: shows the process of masking infected areas in leaf.

IV. IMPLEMENTATION

The proposed system undergoes two main processes:
First process: Is to predict disease in leaf. This is implemented using CNN algorithm.
The implementation steps as follows:
Step1: installation of the libraries. Libraries used to make this work are Tensorflow (Backend), Keras, Matplotlib, Pandas, Numpy, Sklearn.
Step2: load the created leaf dataset that contains leaf images. In this work 3 types of leaf parasites are used including the healthy or normal leaf. The types of parasite leaf used in this work are Bacteria, Fungi and Nematodes. Total no of images used is 241. Also then load the created labels in the format of CVS file which contains labels of each image.
Step3: pre-processes the dataset (leaf images) that is to make sure all the images are of equal size if not then resize all images to same size. Initially size of all images is 256x256. After pre-processing the dataset each image is resized into 350x350.
Step4: once resizing of all the images of dataset is done. Then perform label encoding that is to concatenate each image with its respective label.
Step5: After processing label encoding dataset is split into two parts for training and testing. 80% of the data from dataset is passed for training and 20% of the data is passed for testing. This is processed using library called Sklearn.
Step6: create Convolutional Neural Network model. In this work model is built with 5 layers.

Mode of running the model is sequential. Conv2D filters used to build this model are 16, 32, 64, 128, and 128. Kernel size for all the layer is 3x3. Pooling filter for all the layers is 2x2. Training and testing data is passed to CNN model. Then CNN performs its four operations which are described in system design and architecture (section III). The input image is of dimension 350x350x3 that is passed to convolutional network to which kernel filter 3x3 is applied. A filter is moved one pixel at a time for stride value 1 to obtain feature maps. Now to the feature maps activation function ReLU is activated. After that BatchNormalization function is applied because it helps network to output more stable prediction. Once the feature maps are normalized, to the output MaxPooling filter 2x2 is applied. MaxPooling filter is moved one pixel at a time for stride value 1 to obtain output feature maps which contains only the essential data. Next dropout function is applied to pooled feature maps this will help neurons in the network to reduce the co-dependency amongst each other during training phase so that over-fitting problem is reduced. These same operations are performed by rest of the layers. Then the final outputs obtained from all the five layers are fattened to 1D or a vectored value which will give us the prediction values of the trained data. If accuracy and loss value is satisfied (accuracy value >= 85% and loss value <50%) then consider it as final model and save the weights, use the saved weights to predict the user input image and show the disease prediction obtained.

Second process: is to mask the exact parasite hosted on leaf and is implemented using Mask-RCNN algorithm.

The implementation steps as follows:

Step1: Install the dependencies before using the Mask R-CNN framework.

Step2: Clone the Mask R-CNN repository which has model architecture in it.

Step3: use pre-trained weights these weights are obtained from a model that was trained on the MSCOCO dataset. Download the pre-trained weight file and paste it in the sample folder in the Mask R-CNN repository.

Step4: pass the training, testing and validation dataset to the Mask R-CNN architecture and pre-trained weights. Now mask-rcnn performs its main operations one by one which are described in system design and architecture (section III) to predict mask over the infected areas in diseased leaf.

V. RESULTS

The leaf dataset was divided into two parts that is training and testing for predicting type of disease. The 80% of the data was passed to CNN model for training with batch size 5 and epochs 30 and it result with accuracy value 0.9258 and loss value 0.1964. The 20% of the data was passed to CNN model for testing with batch size 5 and epochs 30 and it result with accuracy value 0.8724 and value 0.4004.

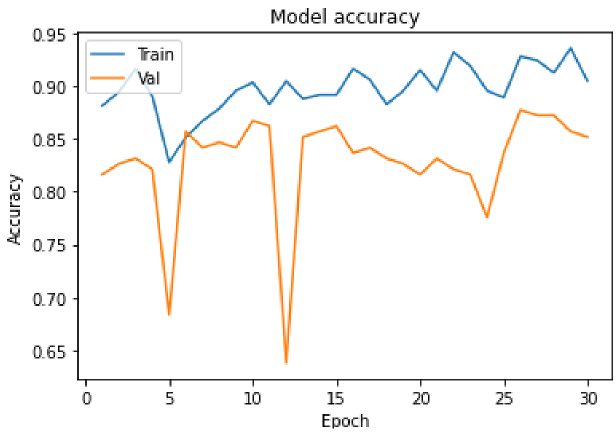


Fig 3: Learning curve graph that shows trained and tested data accuracy prediction values given by CNN model.

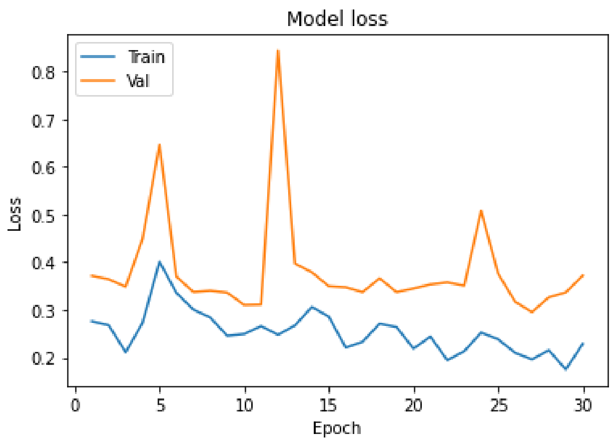


Fig 4: Learning curve graph that shows trained and tested data loss prediction values given by CNN model.

Test results of input images are shown below. It shows results of all the 4 distinct classes those are Normal, Bacteria, Fungi and Nematodes.

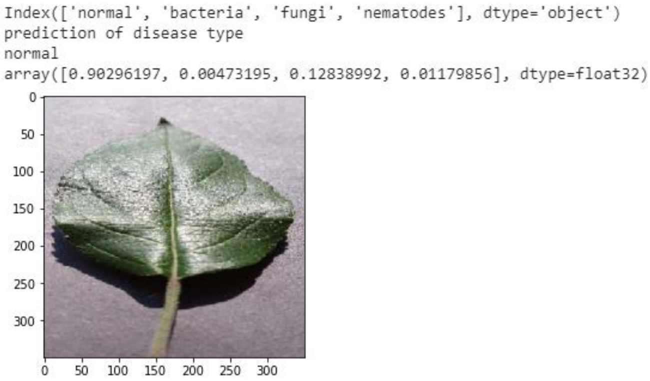
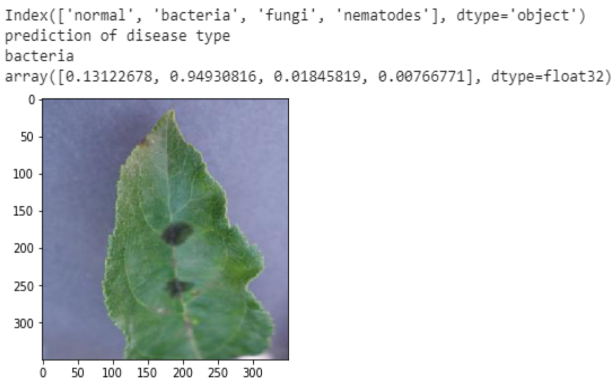
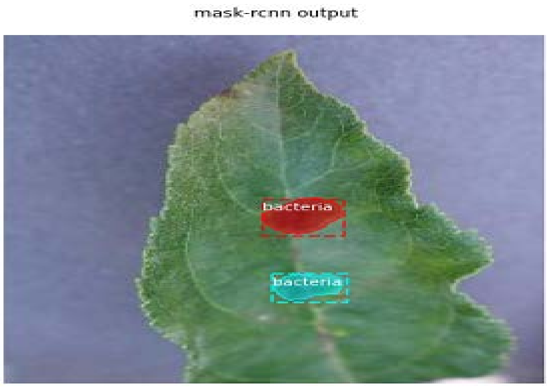


Fig 5: Predicted disease type in leaf is normal leaf.

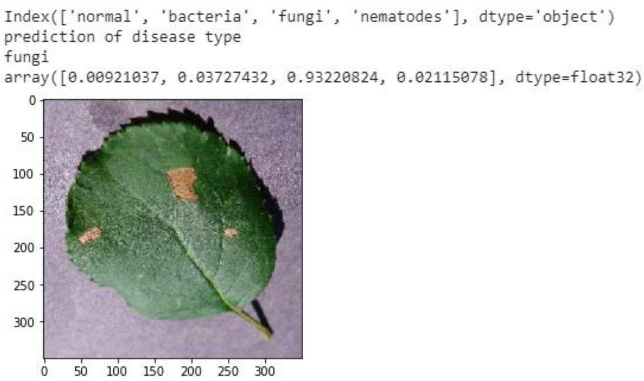


(a)

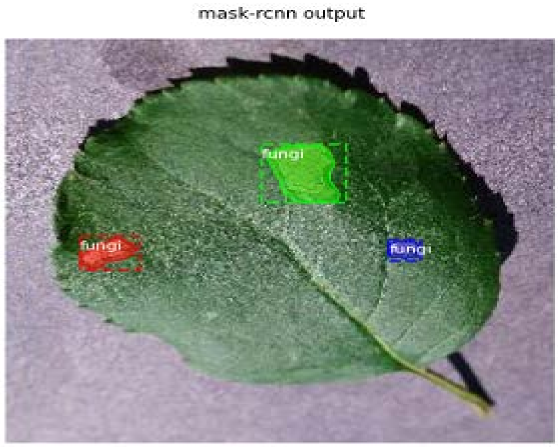


(b)

Fig 6: (a) Predicted disease type in leaf is Bacteria.
(b) Output of masked exact parasite hosted on Leaf.

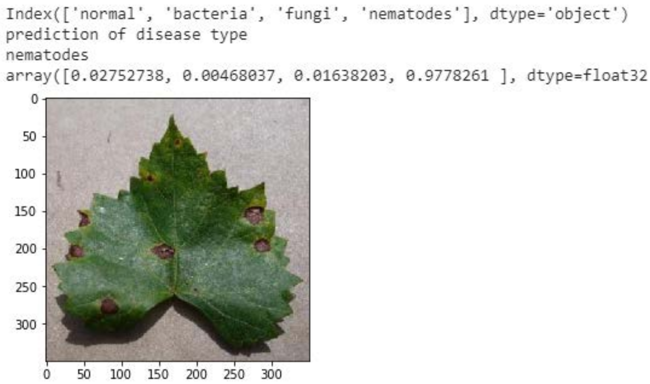


(a)

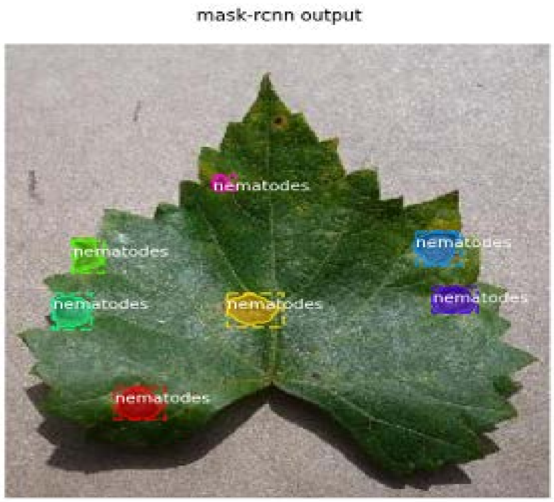


(b)

Fig 7: (a) Predicted disease type in leaf is Fungi.
(b) Output of masked exact parasite hosted on Leaf.



(a)



(b)

Fig 8: (a) Predicted disease type in leaf is Nematodes.
(b) Output of masked exact parasite hosted on Leaf

VI. CONCLUSION

This will provide the information of the possible diseases in leaf and method of identifying the diseases. It is possible to predict three types of disease in leaf using convolutional neural network algorithm including the normal leaf. The model is trained completely and it results with good accuracy value above 85% and loss below 50%. Hence it is successfully able to predict whether the leaf is infected with bacteria type of disease or fungi or nematodes or its normal leaf. Also this project gives an innovative idea to mask the exact portion of pest infected in leaves using "Artificial Intelligence" technique called Mask-RCNN algorithm and it successfully gave accurate prediction for masking. Hence project has succeeded in accomplishing its objectives.

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